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ABSTRACT

This document is the first of a three-volume teacher resource book for use with the Energy 80 energy education program. The program is designed to enhance students' understanding of energy, either through supplements to traditional courses, such as mathematics, science, social studies, or homemaking, or by developing a mini-course or interdisciplinary course in energy. Although written for middle/junior high school students, many of the activities are useful for high school and upper elementary grades. This volume provides information on creating an energy program and characteristics and goals of the Energy 80 program. Additional information provided includes suggestions for involving parents in the program, managing student investigations, reproducing black-line masters, and how energy education develops such basic skills as reading, writing, graphing, and various mathematical skills. An index and glossary to volumes 2 and 3 of this resource book and to "Energy 83" (the student booklet) is included. (JN)

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TEACHING VOL.1 ABOUT ENERGY

1983

Introduction to the
Energy 80 Program

Enterprise For Education, Inc.
Santa Monica, California

Grade Level/
Subject Area

Creating Your Own
Energy Program

Goals

Developing Basic Skills
Involving Parents

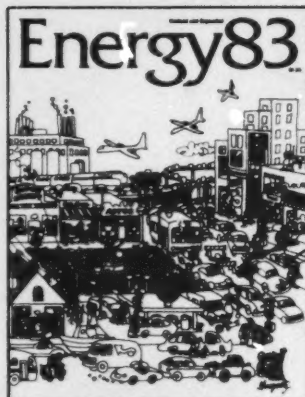
Managing Student investigations

Index & Glossary to the
Energy 80 Materials

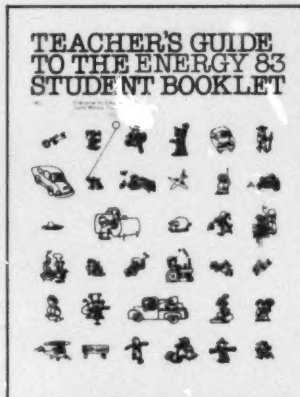
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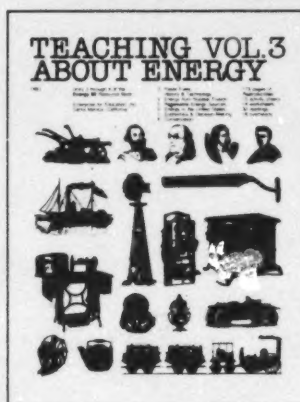
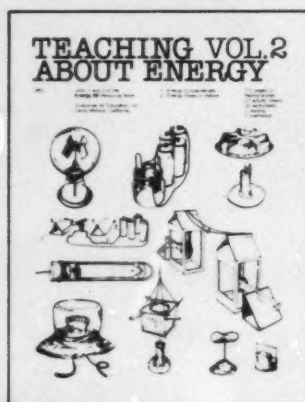


Student Booklet:
A survey of major
energy concepts
52 pages
16 worksheets



Teacher's Guide to
the Student
Booklet:
How to conduct a
well-defined short
unit on energy

Resource Book
Vol. 2:
Energy Fundamentals
Energy Flows in
Nature



Resource Book
Vol. 3:
Fossil Fuels: History
& Technology
Energy from Nuclear
Fission
Renewable Energy
Sources
Energy in the United
States
Economics &
Decision-Making
Conservation

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Footnotes

Energy 83, the Teacher's Guide to the Student Booklet, and this resource book deliberately do not generally include references to the sources of the facts, figures and estimates given. Including these citations would have made the books much more cumbersome, and in our opinion reduced the text's ability to communicate with students. A detailed compilation of references is available for \$10. To obtain a copy, send a check or money order (no cash please) to:

Enterprise for Education, Inc.
1320A Santa Monica Mall, Suite 205
Santa Monica, CA 90401
Attention: **ENERGY 83** Documentation

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TEACHING
ABOUT
ENERGY VOL. 1
1983

Introduction to the
Energy 80 Program

Grade Level/
Subject Area

Create Your Own
Energy Program
Goals

Basic Skills

Managing Student
Investigations

Index and Glossary

The Energy 80 Resource Book

Contents

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Grade Level

The Energy 80 Program

Energy 80 is an energy education project. Our goal is to introduce energy education to as many students as possible in as little time as possible. But we know your school probably hasn't funds these days to experiment with new materials. We know you already have a full day and can't spend a lot of time researching new units.

So, we're providing these materials at no expense to your school or district.

We can make these materials available for one simple reason: the generosity of the organizations listed on the inside back cover of this booklet. They recognize the critical importance of the energy challenge and believe the nation's elementary and secondary schools can help to meet it.

None of the sponsors participated in the development of these materials. Enterprise for Education is solely responsible for the content and has attempted to make the program as free of bias as humanly possible.

Grade Level

These materials are written for the seventh, eighth, and ninth grades, as the most logical grade levels at which to infuse new interdisciplinary subject matter. Most pages in the student booklet have an eighth-grade reading level. Nonetheless, many of the activities in the three volume resource book are useful as high as twelfth grade, and some can be used as low as fifth.

☒ Yes	Middle School/	☒ Yes	Senior High	☒ No	Lower Elementary (grades k-4)
	Junior High	☒ Yes	Upper Elementary (grades 5&6)		

Subject Area

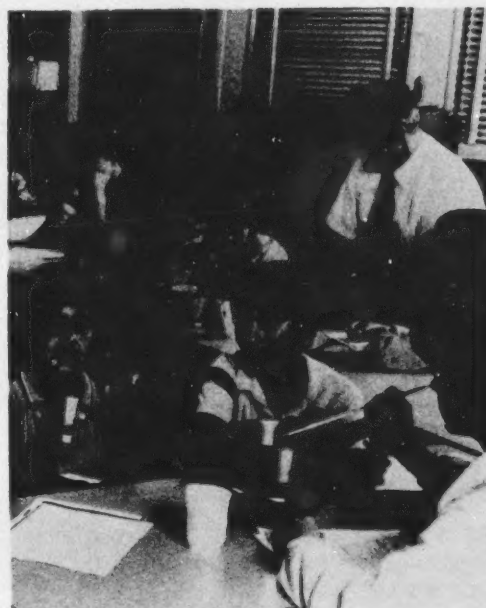
Teaching Energy Within The Context of Another Subject

"Teaching energy is becoming as acceptable and desirable as apple pie in this country. Where to start, what to teach, and how to teach it are basic questions for those of us who work with students in classrooms every day. We already have teaching responsibilities, curriculum assignments and extensive demands on our total time and energies. Anything that will really help us to do our job more effectively, helping students to learn and grow in self confidence, we're grateful for. Instead of adding to our load, teaching energy can actually make it easier to meet our responsibilities more effectively.

"One of the ways to teach energy is within the context of what we're already responsible to teach. No great curriculum revisions are necessary. This approach to energy education has been referred to as INFUSION. It works well. We all know that focusing learning concepts on real situations is educationally sound. Children learn and retain information better. They also gain self confidence and added experience with process. Here's an example: fractional distillation is a separation process covered in many physical science courses. Why would a youngster care about it particularly? However when we approach it from the need to separate the fractions from crude oil so we can get gasoline for our cars, there is a real situation worth considering.

"Experiential learning is preferable to isolated abstractions, especially considering the cognitive growth levels attained by early adolescents. What better opportunity for relating learning to the real world, for gaining information, insight, and practice in community issues and educated decisionmaking than with energy? □ "

An editorial by Bonnie Frimpter & Royal Doughty (junior high science teachers) in the June 1982 Massachusetts Energy 80 Bulletin.



Science

All of the eight units in the Energy 80 resource book contain topics addressed in school science programs. These are taught through laboratory activities: some old warhorses you've done before, some brand new.

Emphasis has been placed on do-it-yourself and the use of cardboard and other inexpensive materials. Reproducible worksheets are provided to guide students through activities.

Topics include:

Physical Science:

- ☐ Energy forms & transformations
- ☐ Measuring energy in the classroom
- ☐ Measuring energy at home
- ☐ Energy flow and efficiency
- ☐ Atoms & elements

Life Science:

- ☐ Photosynthesis & respiration
- ☐ Measuring food energy

Earth Science:

- ☐ Wind cycles
- ☐ The water cycle
- ☐ Fossil fuels: coal, oil & gas
- ☐ Solar energy

American History

Numerous readings from primary sources take the student on a chronological tour of the United States. Readings expose students to energy use in daily life in the following periods:

- ☐ European settlements in the 1600's
- ☐ The young Republic
- ☐ Settlement of the Great Plains
- ☐ The era of industrialization

Some sequences of readings explore social issues like impact of automation on workers and society, and the changing role of women.

Economics

An entire unit is devoted to economic concepts, providing structured activities. Topics covered in this edition include:

- ☐ Scarcity of useful energy
- ☐ Economics of energy supply
 - * Factors of production
 - * Opportunity costs
 - * Productivity of capital
 - * External (social) costs
- ☐ Economics of energy conservation
 - * Embodied energy
 - * Costs of saving energy

The 1983 Edition

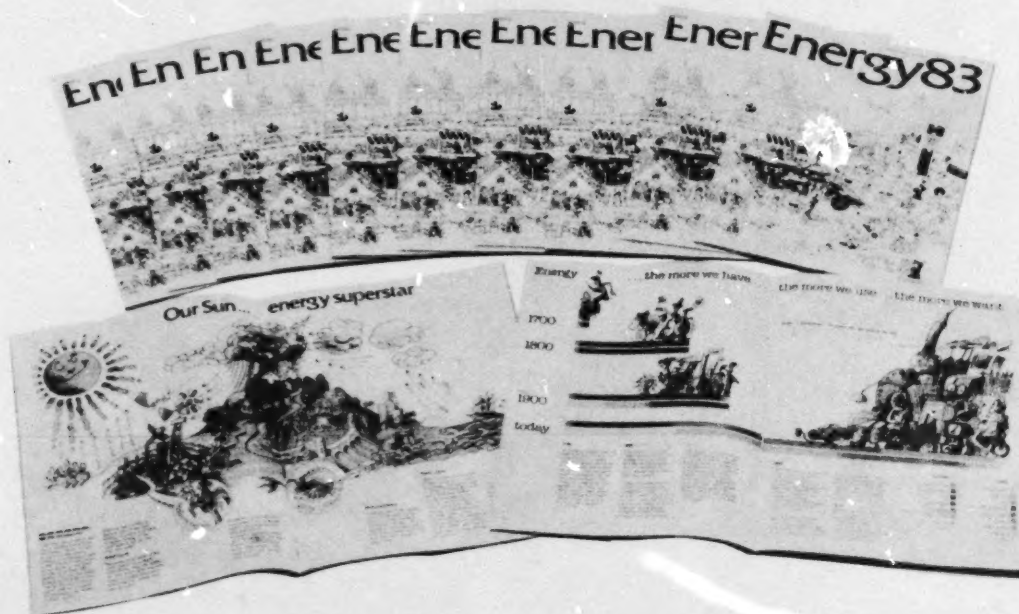
For the Student

For every student in your class, a 52-page illustrated, all-color booklet. Each two-page spread addresses a particular topic. Together, the modules survey major energy concepts in a logical sequence.

Six worksheets review major concepts and reinforce the student's understanding. An additional ten worksheets deal with home energy consumption, emphasizing investigations that might be conducted as a family.

Topics covered in the booklet include:

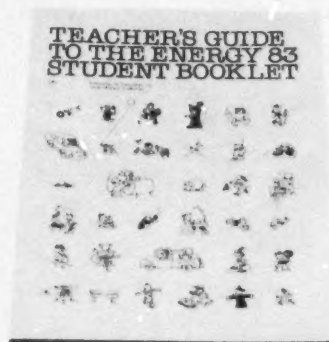
- ☐ Forms of energy & transformations
- ☐ Heat and efficiency
- ☐ Sun, wind, & water
- ☐ Food energy
- ☐ Origin of fossil fuels
- ☐ Coal
- ☐ Oil & gas
- ☐ Nuclear fission
- ☐ Solar technology
- ☐ Energy sources & uses in the U.S. today
- ☐ Buying energy abroad
- ☐ Conservation at home
 - * Climate & comfort
 - * The building envelope (infiltration)
 - * Insulation
 - * Furnaces, air conditioners
 - * Hot water
- ☐ Energy & happiness
- ☐ Conservation in business & industry



For The Teacher

A Teacher's Guide to the Energy 83

Student Booklet contains instructions for conducting a well-defined short unit on energy using the student booklet and selected activities from the resource book.



A three-volume resource book containing lessons and activities that embody accurate, unbiased information. Titled **Teaching About Energy**, it offers seventy lesson plans, each with:

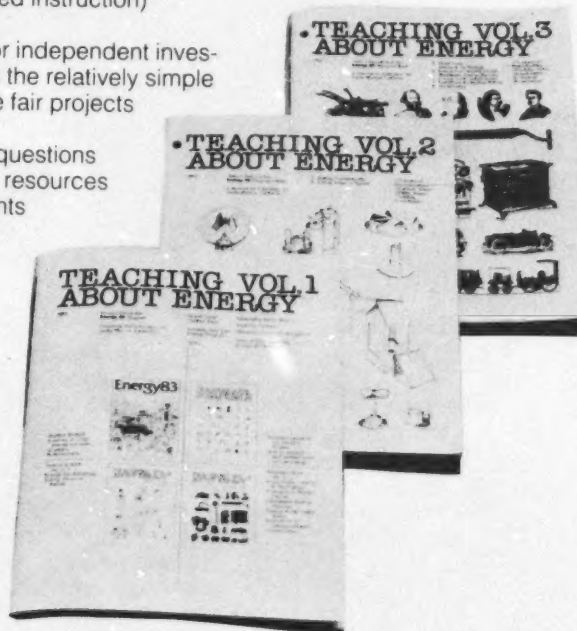
- Objectives
- Materials needed with sources where necessary
- Worksheets spelling out activities in the detail a student would need to work alone (great for individualized instruction)
- Discussion outlines
- Follow-up activities for independent investigation, ranging from the relatively simple to substantial science fair projects

Many also include:

- Readings with study questions
- Five views of additional resources
- Homework assignments

Resource Book Vol. One:

Introduction to the Energy 80 Program



Resource Book Vol. Two:

Energy Fundamentals
Energy Flows in Nature
112 pages of Reproducibles:
27 activity sheets
33 worksheets
1 reading
7 overheads

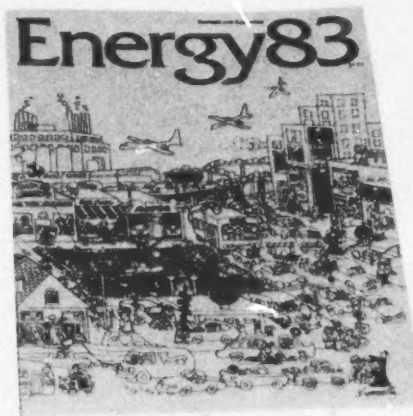
Resource Book Vol. Three:

Fossil Fuels: History & Technology
Energy from Nuclear Fission
Renewable Energy Sources
Energy in the United States
Economics & Decision-Making
Conservation
173 pages of Reproducibles:
15 activity sheets
14 worksheets
32 readings
18 overheads

How To Create Your Own Energy Program

Step 1. Examine *Energy 83*, the student booklet.

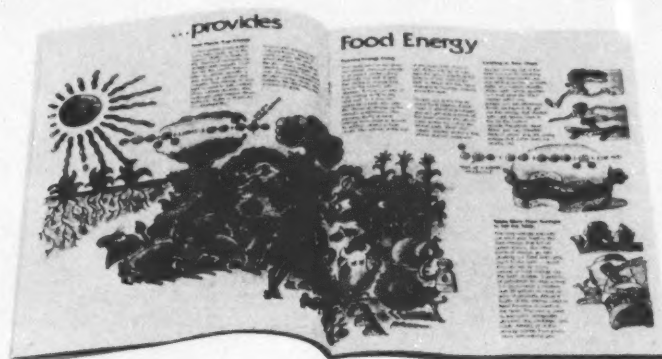
You'll find each two-page spread addresses a major topic. The spreads are sequenced to form a logical progression. Each spread, in turn, contains several sub-topics...each explained by one or more short paragraphs and an illustration. Most sub-topics are supported by a lesson plan and activity in **Teaching About Energy**, the resource book.



Step 2: Select The Spreads You Find Appropriate For Your Program

Most spreads correlate well with a specific subject area. For example, the first two spreads ("In all the universe..." and "Energy...rules of the game") survey energy forms, transformations, and efficiency—all standard physical science topics. The third

spread ("Our Sun...energy superstar") illustrates the wind and water cycles, two earth science topics, and touches upon photosynthesis, a life science topic. Subsequent spreads are relevant for social studies courses.



Step 3. Calculate The Time Required To Teach The Topics Presented On The Selected Pages

The following table can be used to provide an approximate estimate of how long it would take to teach an energy program based on the pages in the student booklet you select.

First enter a "✓" in the box next to each spread that you have selected. Then circle the number in the column that reflects your degree of interest in each selected spread ("high,"

"moderate," "minor"). Numbers represent classroom periods. The "high interest" column number represents the number of classroom periods suggested in the **Teacher's Guide to the Energy 83 Student Booklet**. This should allow time for in-depth classroom discussion and one or more activities taken from the resource book. The "minor interest" number assumes no activities are conducted and exposure to the spread is limited to students reading the spread followed by modest classroom discussion. The middle number reflects the midpoint of the two.

Next add the circled numbers in each column, then add the three column totals. This is the approximate program total in classroom periods. If the result is too high, consider a program based on the higher interest spreads and omitting the lower interest spreads.

After you have read the materials from the guide and determined how you will teach the selected subjects, you should modify your estimate to take into consideration the age and ability of your students, the extent of class discussion, the number of activities, etc.

Please view this estimate as preliminary.

Estimating Your Use Of Energy 80 Materials (in classroom periods)

✓ Selected Spread	Page(s) in Student Booklet	Title of Spread	Your Degree of Interest			If selected, remove these pages from Teacher's Guide
			High	Moderate	Minor	
☐	Inside Front & 1	Message from official & record of energy knowledge	1	5	5	11 & 12
☐	2-3	In all the universe there is only energy and matter				
		☐ Subtopic—matter and energy	2	1	5	13 through 16
		☐ Subtopic—Measuring energy (see Teacher's Guide to booklet, pages 17-20)	2	2	2	17 through 20
		☐ Subtopic—Measuring energy used in the home (see Teacher's Guide to booklet, pages 21-24)	4	2	1	21 through 24
☐	4-5	Energy...rules of the game (efficiency)	3	2	1	25 through 30
☐	6-7	Our Sun...energy superstar (wind & water cycles)	2	1	5	31 through 34
☐	8-9	...provides Food Energy	2	1	5	35 through 40
☐	10-11	Fossil Fuels...super long stored-up food energy	1	1	5	41 through 44
☐	12-13	(worksheet reviewing energy forms)	1	1	1	45
☐	14-15	Coal: the once and future king?	2	1	5	47 through 52
☐	16-17	Oil & Gas Production & Consumption	2	1	5	53 through 56
☐	18-19	Energy from Nuclear Fission	2.5	1.5	1	57 through 64
☐	20-21	Energy for the next ten thousand years (solar energy)	3	2	1	65 through 70
☐	22-23	(worksheet reviewing energy sources)	1	1	1	71
☐	24-25	Energy...the more we have...the more we use (sources and uses from 1700 to today)	3	2	1	75 through 80
☐	26-27	Energy Production & Consumption (current)	2	1	1	81 through 84
☐	28	(worksheet for pages 24-25)	Included in 24-25			85
☐	29	(worksheet for pages 26-27)	Included in 26-27			86
☐	30-31	Investing in Energy	2	1	5	87 through 94
☐	32-33	Buying Energy Aboard	1	1	5	95 through 98
☐	34-35	Saving Energy Dollars at Home	1	1	5	99 through 102
☐	36-37	Climate and Comfort	2	1	5	103 through 108
☐	38-39	The Building Envelope: Infiltration	1.5	1	5	109 through 112
☐	40-41	Insulation	2	1	5	113 through 116
☐	42-43	When You're Hot...	2	1	5	117 through 120
☐	44	Getting Into Hot Water	1	1	5	121 through 124
☐	45	(Home conservation review)	1	1	5	125
☐	46-47	Energy and Happiness	3	2	5	127 through 131
☐	48	Energy Saving at Work	1	1	5	131 through 134
Column Totals (add only numbers you have circled)						
Program Total (the sum of the three column totals)						

Step 4. Place The Energy 80 Materials You Need To Support Your Program In A Three-Ring Binder

To accomplish this, transfer the pages shown in the above table from the **Teacher's Guide to Using The Energy 83 Student Booklet** to a three-ring binder. (The Guide is purposely bound with a minimum of glue.)

Once this is done, remove from the resource book (**Teaching About Energy**) the lesson plans and activities specified in the Guide's discussion of each spread. (This is located in the top left corner of the first page that discusses the spread.) Place the resource book materials behind the appropriate Guide write-up. Consider using tab dividers to separate the materials for each spread.



Characteristics of the Energy 80 Program

Congratulations. You have a chance to teach students about one of the most exciting subjects there is: energy.

No other topic reveals as much about their present and future lives—or yours. Nothing else is part and parcel of everything we make, see, and do. Much of the price of the automobile you bought, as of houses, corn flakes, shirts, and radios, is energy costs. Our worst pollution problems are created in obtaining and using energy. Historically, the ability to manipulate energy helps explain why the North won the Civil War, and why the Roman and British Empires rose. Energy is part of *you*—every beat of your heart started in a nuclear reaction thousands of years ago in the sun.

Energy is as stimulating a subject for a teacher as for students. No matter how much one learns about energy, there's always more to learn. The state of our knowledge of energy and its social implications is evolving rapidly. Each year new insights appear and new techniques are invented—or prove commercially unfeasible. If only for this reason, energy cannot be taught as one might teach, say, long division. Nobody can answer all the questions a class can ask. What we certainly can do, though, is heighten our informed awareness of energy's role in our lives. This is a task you and your students can undertake together—and will find tremendously satisfying.

One of the goals in preparing these materials has been to make them easy to use.

We have tried to provide the basic information you will need to teach about energy at the junior high school level, and we have tried to do as much of the preparation work as possible. We assume you will want to change these lessons to make them suit your particular students and school system.

Energy is inherently an interdisciplinary subject. It isn't possible to understand its social effects if you don't understand at least some of the technical aspects, and an understanding of the physical and engineering aspects is worse than useless without an appreciation of the human implications. Recognizing this, you may be teaching a course in social science, math, or science, and want to introduce some energy-related concepts.

In creating these materials, we have tried to follow a few principles we think lead to effective education.

Fun

Young people experience intensive learning as fun. If they are not having fun, part of their potential for growth is not being engaged. The activities, examples, and exercises have been selected not only for what they teach, but also because students have—at least in some circumstances—found them to be fun.

Success

Students need to succeed at anything you expect them to continue doing. Usually we underestimate how frequently they need to succeed. We have tried to build into the materials frequent occasions for success. Nevertheless, only *your* on-your-feet sensitivity what's going on in your classroom can make this principle work for your students.

Stretch

Success is meaningless to a learner who feels it was too cheaply won. We feel a teacher needs to have at hand relevant challenges which will tax the abilities of her most able students and not just fill their time. Such challenges are included, for example, in the section **Projects for Independent Investigation** at the end of each lesson plan.

This course work lends itself to adaptation to a broad range of interests, abilities, and learning styles. In adapting this material to suit your class, please take care not to accidentally lop off all the activities that require out-of-the-ordinary perseverance, talent, or intelligence on the part of your students.

Risk and Gain

Nothing ventured, nothing gained, but in our concern for students' safety (and our own exposure to liability), we have sometimes been too willing to sacrifice opportunities for growth. In recent years, however, many excellent schools have been allowing primary children to cook, use scissors with effective edges, and engage in other activities that would have been frowned upon a few years ago. In this spirit, activities have been included in which a small amount of risk cannot be separated from a large chance for learning. Special notes point out particular safety considerations.

Some of the difficult decisions that had to be made in the course of developing these materials may require some explanation:

Units of Measurement

The standard Systeme International ("metric system") unit of energy is the joule. We decided not to use this unit to introduce the measurement of energy because it is difficult for students to associate with their experience of energy. The calorie, though not strictly an SI unit, is more workable because it is easy for students to measure temperature and mass and thus form a mental image of the nature and size of a calorie.

More controversial was the decision to make use of the calorie's non-metric counterpart, the obsolescent British thermal unit. We do so because:

(1) The ratings plates and energy efficiency labels students encounter on refrigerators, air conditioners, water heaters, and furnaces, are in Btu's. The definitions of the EERs of air conditioners and the R-values of insulation involve Btu's. Utility bills usually state natural gas sales in *therms*, and a therm is simply 100,000 Btu's.

(2) The popular press ordinarily uses Btu's (for example, in articles comparing the fuel value of gasoline and diesel fuel). The *quad*, often encountered in articles on national energy use, is simply 1,000,000,000,000,000 Btu's.

(3) The United States government keeps its energy statistics in Btu's. (These statistics are available to students in public libraries).

Familiarity with the *de facto* standard unit helps to make the energy information students encounter outside of school meaningful to them, and that contributes to their developing an understanding of energy use in their daily lives. We believe that students trained mainly in joules cannot realistically be expected to perform mental conversions from Btu's to joules, and thus that not using Btu's amounts to throwing away some of the educative value of the student's environment.

For the British thermal unit, we use the abbreviation, Btu, without periods, following **A Manual of Style** (twelfth edition revised, University of Chicago Press, 1969). For SI units, we use the abbreviations suggested by the National Bureau of Standards, including mL for milliliter and kWh for kilowatt-hours.

Projections

Projections of future energy demand or supply are an essential tool for planners and policymakers. Such projections are readily available in periodicals and government and industry publications. However, we take the position that in practice most students mistake projections for history written in advance. For that reason, we do not use projections, except in activities in which students develop the projections themselves—a situation in which they retain a healthy skepticism about the author's prescience.

Goals

This program has four major goals:

- To heighten the students' awareness of the pervasive role of energy in their lives and in the economy.
- To give students hope by making them aware of possibilities for constructive innovation in energy use and supply; for example in improving the efficiency with which energy is used.
- To develop specific skills which will increase students' competence in using energy, such as fuel-efficient driving or life-cycle costing.
- To impart enough technical and scientific background to support knowledgeable participation in public discussion and sensible energy planning at home and on the job.

Ultimately, achievement of these goals can only be measured by the way students act when they become adults. As a mental aid in defining the above goals, here are a few actions we would consider evidence of successful energy education:

Graduates would, on the average, spend less on energy than non-graduates with comparable incomes.

Faced with a choice between two alternatives, one involving reduced consumption of fossil fuel but a higher initial investment in equipment, all other things appearing equal, including benefits and life-cycle cost, graduates would choose to make the higher initial investment.

Graduates would expect increases in energy costs to be reflected in increases in the costs of most goods and services.

Graduates about to purchase a major appliance would work out, for the models they were considering, the cost of electricity or gas consumed by the appliance over its lifetime.

Graduates choosing a residence would work out an estimated budget for living there that would take into account energy costs in transportation, recreation, heating and cooling.

Graduates purchasing a home would seriously consider innovative alternatives in heating and cooling systems, such as the use of heat pump systems, or passive solar designs.

Graduates would be more likely than non-graduates to reject claims for perpetual motion machines.

Graduates would be conscious of the energy efficiency of machines and systems they used at home and at work, and would be more likely than non-graduates to seek means of raising efficiencies.

Graduates would take a more active role than non-graduates in supporting energy legislation they felt was in the best long-term interests of the United States.

A New Place

He had a iron plow, a breaking plow, it was wonderful for breaking the ground and it had a sharp edged wheel called a rolling coulter, that can rolling and cutting through the soil ahead of the plowshare. The sharp steel plowshare followed it slicing underneath the material as it broke, and the mold board lifted the long, straight-edged strip of soil and forced it upside down. The strip of soil was exactly twice as long as wide, and as straight as if it had been cut by hand.

Be aware that plow can handle the work by itself, he said. With all these new implements nowadays, there's no use for a man's muscle. One of these nights that plow will take a notion to keep its going, and we'll look out in the morning and see that it's turned over an acre or two after the team and I quit for the night.



The **2000** **Top 10** **Country** **Albums** **of** **the** **Year** **are** **as** **follows**:
 1. **Garth** **Brooks** **and** **the** **Brooks** **Band** **—** **"The** **Cherry** **Pie** **Album"**
 2. **Garth** **Brooks** **—** **"The** **Cherry** **Pie** **Album"**
 3. **Garth** **Brooks** **—** **"The** **Cherry** **Pie** **Album"**
 4. **Garth** **Brooks** **—** **"The** **Cherry** **Pie** **Album"**
 5. **Garth** **Brooks** **—** **"The** **Cherry** **Pie** **Album"**
 6. **Garth** **Brooks** **—** **"The** **Cherry** **Pie** **Album"**
 7. **Garth** **Brooks** **—** **"The** **Cherry** **Pie** **Album"**
 8. **Garth** **Brooks** **—** **"The** **Cherry** **Pie** **Album"**
 9. **Garth** **Brooks** **—** **"The** **Cherry** **Pie** **Album"**
 10. **Garth** **Brooks** **—** **"The** **Cherry** **Pie** **Album"**

They were all so happy about that new place. Now, after a while they work. Sam and David go to the school and collect and pickled their ears and looked about the garden before they fell to rapping grass. They were not being mean, though, said and gazed, but breaking out that spring. And at night, the stars and stars tried to make

Reading Carefully

1. Why was the place called a "breasting place"?
2. Why were the girls happy about it? Why were Sam and David happy about it?

Thinking It Over

1. What benefit did Pa get from the new plow? What extra costs did Pa incur to get these benefits?
2. How have incentives changed the relative importance of brain and muscle?

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Readings are accompanied by questions that require, not just simple recall, but also "higher level processes" such as analysis and synthesis.

Readings 1000hrs - 1200hrs

Gas Diary: One Week

During one week, every day, at the same time of day, read your family's gas meter. Of course, if you wanted to measure exactly by days, you would have to read the meter at midnight. But a good practical time to read it is before going to school or after dinner.

Chen et al.

Day of Week	Time of Reading	Reading	Cubic Feet Used in Last 24 Hours
Sunday			
Monday			
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			

Use this form to make a bar graph of your weekly gas consumption.



(Do you notice any bumps? What caused them?)

Save this sheet. In a different session, do the activity again and see if your pattern of consumption has changed.

Energy Education Develops Basic Skills

Not something else to be shoved into the curriculum! Energy on top of drug education, sex education, driver education, global education, consumer education...! Where will it end? Where will we get the time, the money? What's the point?

One point is that many knowledgeable people think public understanding of energy is a survival skill for our society, that needs to be taught just as we need to teach what to do in case of a fire at school. However, this is not the place to discuss why some people believe this. Besides, it isn't necessary to do so, because from an educator's point of view that is not the only reason for teaching about energy — maybe not even the best reason.

Teaching Kids to Think

Using energy as a topic may be a better way of accomplishing things you're already trying to do. You try to prepare young people to be competent, productive adults — happier and more effective than they would have become without the benefit of your teaching. Perhaps most important, whatever their subject area, good teachers try to teach students to think and to value thinking. You help your students learn how to marshal information, for example, and how to reach conclusions.

No subject matter deserves to be introduced into the curriculum at the expense of developing students' ability to think. On the other hand, teachers are always looking for topics that set students thinking. Good teaching about energy is **not** primarily teaching a bunch of facts about energy: acquiring facts is a means to an end. Energy education is much more concerned with developing the students' ability to think about energy supply and use. To accomplish this, energy education must exercise and develop the students' basic skills.

Basic Skills Aren't Content-Free

Some parents today say they want basic skills taught, and nothing else. By "basic skills," many people simply mean reading, writing and arithmetic. In fact, these three skills do deserve a prominent place. Without them a student would have a hard time coping with the world: difficulty getting information, difficulty communicating with others, and no hope at all of using the power of mathematics to describe and predict the framing of a house or a family budget, let alone the performance of a machine.

Because these basic skills are ways of communicating and describing, they cannot be developed in a vacuum. A student has to read and write **about** something. A student whose only exposure to arithmetic is "number fact" drills will find it hard to apply his knowledge of those facts to the real world. Context is unavoidable. Educators try to pick the optimum "something."

Often we ask — or allow — students to read and write about summer vacations, arcade games, and favorite TV shows; or to calculate about apples and oranges, tickets and allowances. This provides practice, and students can learn to read, write, and reckon using such subjects. But is this the best we can do? Is it all we should do?

Energy, a Holistic Subject

The problem with subject matter like arcade games is that in a sense it is impoverished; the skill being developed leads somewhere but the content doesn't. An acquaintance with such content casts little light on the rest of the universe. Serving the limited purpose of the moment, it is quickly over and done with. It affords little opportunity for the class to see the teacher reason about something, little opportunity to participate in that reasoning.

Energy, on the other hand, always leads somewhere. It leads everywhere. Of all topics, it is the one which, whatever strand you pull, you find connected to a hundred surprisingly different things. A basic understanding of energy illuminates our society, our history, our economy, life on the planet, the birth and death of the universe. As a context in which to develop skills, energy is exceptionally rich food for thought.

The variety of energy-related topics also presents an advantage for the student: it facilitates fairly rapid rotation of modalities. Energy education is like the New England weather: if a student doesn't like today's lab activity, she can have a reasonable hope that tomorrow she will be investigating life in the 1800s — yet the second lesson can develop logically from the first. And the subject of energy provides scope for the enthusiastic vagaries of young peoples' curiosity.

The honest skeptic may be thinking the same claims could be made for biology, Latin, or mathematics. But, can you find any aspect of the world that you think is worth teaching about in which energy does not play an *essential* role? While we believe you cannot (and easily can for, say, Latin), the only way you can satisfy yourself on this point is to try it.

The use of a strongly interdisciplinary topic like energy seems particularly appropriate at the middle school level, an age at which young people are coming into a new stage of reasoning and acquiring new powers which need to be exercised. Studying energy is one way of giving them a glimpse of the forest, before they go on to study the trees represented by the various discipline-oriented departments of the modern secondary school.

Energy, a Relevant Topic

A second benefit of using energy as subject matter for learning basic skills is that it is part of the students' daily lives at home and at school. Certainly "relevance" has been overemphasized in the past decade, but it's still true that it is easier for students to relate to subject matter that connects with what they see going on in their immediate environment. The more meaningful the content is to the student, the more meaningful acquiring the skill will be.

Using Energy to Develop Basic Skills

Because of its explanatory power and because of its relevance, we believe energy is a much better than average "something" to read about, to write about, and to calculate about.

Built into the **Energy 80** materials are numerous opportunities for learning and practicing basic skills. Some of these opportunities are pointed out below.

(We don't mean to imply by this emphasis that school work should be restricted to reading, writing and arithmetic. These are necessary skills, but it seems unlikely they will be all that the productive citizen will need in 1999.)

Reading

Students at upper elementary level and beyond should have passed the initial stages of learning to read. Now one of their primary needs is practice in "reading for meaning," as opposed to simply translating printed symbols into oral language. To become aware of the extent to which he or she is grasping the meaning of what is being read, and to benefit from others' examples, every student needs an opportunity to write or talk about what he's read with fellow students and the teacher, so that he can receive feedback from them.

The student booklet provides a limited amount of reading material with copious illustrations. Almost everyone in a typical junior high class can be expected to read it, and thus obtain the basic facts needed for participation in class discussion. Other readings can be chosen from this resource book on the basis of the teacher's judgment of their appropriateness to the abilities and needs of his or her students.

For example, the teacher can choose from 47 pages of readings from historical primary sources (unit 3, unit 6). Each is accompanied by study questions which may be assigned at the option of the teacher. One set of questions asks for simple recall: can you find this information in the reading? A second set requires "higher level processes" such as analysis and synthesis. For most readings, a third set is provided that asks the student to locate additional information in other sources.

Readings are also provided in topics such as energy economics. These are not from primary sources, and so as a rule it has been possible to control the reading level at a lower grade level than it is reached in some of the primary sources.

Studying energy also provides opportunities for careful reading of articles from current newspapers and magazines. There are many points of view on the energy situation, and more material on it appears in print everyday. Classes with a good grounding in energy issues are prepared to examine and discuss not only the arguments presented, but also the manner in which the authors have expressed their views.

The useful skill of map reading is also developed through discussion patterns provided in those lessons in which maps play a part.

Writing

Teaching students how to write something meaty involves teaching a number of skills, many of which can be developed separately. For example, part of learning to write is learning how to locate needed facts, "library skills." *Finding Out More Information*, a section of questions that accompanies most readings, often includes suggestions for library research, as does the section *Projects for Independent Investigation* at the end of most lesson plans.

Another skill needed in writing is the ability to organize one's thoughts. One way students can acquire this skill is through oral presentations. On a small scale, **Energy 80** lessons make extensive use of group work and suggest oral presentations to the class of the results of group work. Suggestions for appropriate topics for more ambitious presentations are provided in many lesson plans. Certain lessons are built around class debates; such lesson plans include background information for individual debaters, as well as suggestions for finding additional information.

If the teacher chooses to do so, the assignments can be carried one step further to become a written presentation. Unfortunately, teaching loads often severely limit the number of written assignments a teacher can grade. For this reason, writing assignments are left to the discretion of the teacher.

Mathematics

Our society needs "numeracy" as much as it does literacy. Schooling helps students master computational skills, but it must also create a predisposition in students to try to use numbers to describe the world around them and to predict its behavior. The latter is the greater challenge; many students who can do their sums accurately have trouble with "story problems," and wouldn't dream of actually using math to attack their real-life problems. Skill and confidence can come from successful practice. Energy education affords numerous opportunities for exercising both computational skills and story problem skills.

Quantitative laboratory activities are provided, even in the life sciences. Students enter the required measurements on worksheets which *guide them through simple mathematical operations* that relate one piece of data to another. In addition to exposing students to how scientists use numbers to describe reality, such orderly data gathering builds good lab habits, and helps to prepare students for further laboratory science at higher grades.

Students also collect and work with data on energy use in their own lives, and this exposes them to the practical use of various types of mathematics. Area? Measure the area of the windows in your home and calculate the dollar value of the heat lost through them. Angles? Measure the changing bearing and altitude angles of the sun, and calculate the depth of an overhang needed to shade your windows. In many of the economics lessons, students deal with the dollars and cents of energy in their lives, as well as other quantitative aspects of economics.

Graphing

As part of revising its junior high/middle school science curriculum, one school district asked its secondary science teachers to list in order of importance the knowledge and skills they wanted students coming to them to have acquired in elementary and junior high science. The ability to read and construct graphs emerged at the top of the list. **Energy 80** provides numerous opportunities for students to collect and graph data, usually providing prepared forms. In addition, graphs are used in the presentation of data, for example, as in masters for overhead transparencies.

Other Skills

Many skills besides reading, writing, and arithmetic are developed in this resource book. Some of these are useful if mundane (how to read a thermometer, how to read a utility meter). But we have also made an effort to expose students to simple forms of some of the newer tools people use, since these may be the basic skills of the future: for example, using charts to track complex flows, as programmers and construction workers must (the lesson **Lead-time**, the energy flow chart in the student booklet); thinking in terms of systems, both natural and manmade; and life-cycle costing.

Involving Parents

Energy education offers special opportunities for involving parents. Many energy-related topics are best taught through activities which parents and children do together, and even some that aren't interest parents, since they address pocketbook issues in their own household. Other activities can involve parent volunteers in helping the entire class and enjoying doing so.

Protecting the Privacy of Families

The more closely energy education relates to what students see going on about them, the more effective it is. It's almost essential that students collect and analyze information on their own use of energy, in their own households. But if you let it, sharing this personal information with other members of the class can lead to bad feelings, particularly if there are large income differences in the class. Parents, rightly anxious to protect their privacy, also can be offended by clumsy use of information about their homes.

For class use, for example at the chalkboard, use typical figures rather than figures drawn from a particular family, even if you do not name the family. You need not calculate an average figure; simply make a rough estimate that will be within the range of figures for your students' families. Some teachers use their own utility bills.

To prevent misunderstandings you may wish to send a note home with the students at the beginning of the unit. The note might read something like this.

"Dear Parent,

This semester students in the —th grade will be studying energy, partly to help them become better-informed energy-buyers as adults. To do this each student needs to collect information on his or her own energy consumption. Your child and I would appreciate your help in gathering the necessary information.

Worksheets will be sent home on which your child can enter this information. After your child has finished all the calculations, she or he will share the results with you. I hope you'll find them interesting. Your child may even discover some ways you could save money.

The information about energy consumption that your child collects is only for his or her own use. Students are not required to share the information with other students. Please be assured I'll protect your privacy.

Sincerely,

Ms./Mr. Teacher"

Be prepared to provide considerable leeway in an assignment asking students to collect energy data. A set of detailed instructions will often be unsuitable for some students, because homes differ physically, and because some parents have more free time in which to help their children than others. For example, a student in a 50-story apartment building can attempt to investigate his or her water heater, but completion of such an assignment cannot be required.

Teaching Conservation

How is energy conservation best taught? We feel that a moralistic, "Moses-speaking-from-the-mountain" attitude toward conservation is not only ineffective, but can also have many bad side effects in the classroom. Continual moralizing is a put-down of students who discover their families are heavy consumers of energy, something for which they are not, after all, responsible. (Obviously you would not make explicit comparisons between the families of two students.) Many students take teachers as role models, but preaching to a parent with fuel-wasting driving habits is bound to create family friction. Such considerations don't preclude teaching a positive attitude toward conservation; they only illustrate that some ways of doing so are more effective than others.

To form a lasting, positive, attitude toward conservation, students need 1) to make up their own minds about its value, and 2) to be able to recognize opportunities to conserve. You can give them a chance to see what conservation means. You can also teach them the principles that underlie energy management, such as the concept of energy efficiency. This will be much more effective in the long run than teaching a bunch of tips which may be out-of-date by the time your students are adults.

Conservation is the last topic in the **Energy 80** sequence, but not because it is least important. Rather, we feel that the more students know about what energy is, and how we have used it and are using, the more they will appreciate the value of conservation and the easier it is for them to grasp how the various conservation methods work.

Help from Parent Volunteers

Help from parents can take many forms. They can:

- scavenge materials (e.g., collect baby food jars and other substitutes for lab equipment)

- build apparatus for activities and demonstrations

- assist in the classroom with activities

- arrange for field trips

- advise students working on independent projects

- arrange for classroom visitors

- grade certain types of assignments

What you can reasonably expect parents to do depends on the skills of your students' parents, and the amount of time they have available. In many communities less help is available than formerly, as more mothers take full-time jobs. Under these circumstances, to increase the amount of help you get from parents, let them know there are many things they can do which will fit into **their** schedule.

The first step is to communicate with the parents. You may have an open house or parents' night where this can be done, or you might wish to send home a letter.

What you want to tell the parents:

You can use help; that help can contribute to their child's education.

Help on a regularly-scheduled basis is very useful; but many projects are one-time affairs.

There are many things fathers could do.

List examples of the kinds of things you would like to have done.

What you want the parents to tell you:

Occupations (like plumber, carpenter, doctor, electrician, accountant) and hobbies (like potter, electronics buff, gardener) are often clues to skills that would be useful.

Whether they could contribute time during class or outside of school hours.

The big problem in using parents is to make sure that supervising the parent program does not take more of your time than you would have needed to do as much good for the students yourself. The single most valuable type of volunteer is one who is good at organizing volunteers, someone organized, diplomatic, well-liked by other parents, and willing to spend time on the telephone.

One way of economizing on the demands put on the time of people with the harder-to-get skills is to give the preparation to other people. For example, it takes a skilled person with the right equipment and skills less time to make most apparatus than it takes to accumulate the materials. Similarly, rather than split a job up by asking two parents to each make 10 of something, consider giving the whole job to one individual. Preparing to do the job is often the most time-consuming part of doing it.

Measuring Food Energy Worksheet

Peanut Calorie Calculation

Amount of water used = _____ milliliters = _____ grams

Temperature of water in °C before burning peanut = _____ °C

Temperature of water after burning peanut = _____ °C

Difference in temperature = _____ degrees

Calories = (mass of water in grams) x (temperature change in °C)

An example:

Ten grams of water are heated 15 °C.

Calories = (10 grams of water) x (15 °C)

Calories = 150 calories

Use the above formula and your measurements to calculate how many calories of heat were obtained from the peanut.

Calories = _____ grams x _____ °C

Calories = _____ calories

This calculation is in small calories. There are a thousand calories in a food Calorie, or large Calorie. To convert calories to Calories, divide the number of small calories by 1000.

Example:

large calories = small calories / 1000

Calories = 150 calories / 1000

Calories = 0.15 Calories

How many food Calories did burning the peanut add to the water?

Calories = _____ calories / 1000

Calories = _____ Calories

Energy 90

Quantitative laboratory activities are provided. Students enter the required measurements on worksheets which guide them through simple mathematical operations that relate one piece of data to another....Such orderly data gathering helps to prepare students for further laboratory science at higher grades.

Measuring Food Energy

Light the peanut with a match. As soon as it starts to burn on its own, place it under the can in the calorimeter and allow it to burn.

If the peanut squirts and goes out before it cools all burnt up, get a new peanut and fresh water, and start over.

When the peanut cools all burnt up, and goes out, take the temperature of the water again. Record the temperature on your worksheet.

Step Five: Calculate the calories.

Step Six: Repeat the procedure with a marshmallow.

Step Seven: Calculate the total calories from all the materials burnt where they belong.



Energy 90

A Nutty Way to Measure Calories Activity

Does eating a peanut give us more energy than eating a marshmallow? You can find out by measuring the number of calories of food energy in each. A calorie is the amount of heat needed to raise the temperature of one gram of water one degree Celsius. One gram of water has a volume of one milliliter.

Check to see if you have all the materials you need:

- ☐ one wire coat hanger
- ☐ one aluminum can
- ☐ aluminum foil
- ☐ clay
- ☐ straight pins
- ☐ peanuts, gum-marshmallows
- ☐ piers
- ☐ graduated cylinder
- ☐ Celsius thermometer
- ☐ matches
- ☐ water

Procedure

Step One: Untwist the coat hanger to get a heavy wire. Wrap the wire around the can in the shape of a spiral. Make the lower turns of the spiral tighter, gradually increasing the size so it makes a base about 6 to 10 cm.




Step Two: Cover the spiral of wire with aluminum foil. Leave an opening for a flame.

Step Three: Measure 100 milliliters of water and place it in the can. What is the mass of 100 milliliters of water? Take the temperature of the water. Record your measurement on the worksheet.

3-47

Managing Student Investigations

For those who are not accustomed to doing laboratory science in their classrooms, here is some advice:

Breaking In the Class

Expect that it will take a while to get started. Students who have never done lab work may tend to run amok until this kind of classroom activity becomes familiar. Don't despair if the first lab seems chaotic. The more investigations you do, the easier it becomes for everyone. DO insist on consistent routines from the first lesson. In the first few lessons, give first priority to establishing these routines; second priority to "covering" the subject matter.

The First Lesson

Spend some time at the beginning of the semester acquainting students with how the equipment and supplies are organized, how they are to be obtained, and how to put them away. You may want to make some dry runs by giving students lists of materials and having them get out the equipment and then return it.

Be sure students understand your school's rules about under what circumstances, if any, students pay for broken equipment.

Go over all safety measures. Show students where the fire extinguisher is, where the nearest running water is, where the eye-wash station is (if you have one), where the safety shower is (if you have one), and so forth.

Form Work Groups

The directions for most of the activities in the Energy 80 materials assume students will work in groups.

Running investigations as group activities has a number of advantages, not the least that it makes equipment and materials stretch a bit further. More important, interac-

tion with peers helps students mature, and it often increases their attentiveness and retention of the subject matter. Also, certain students who would be unable to carry out an investigation on their own can often participate actively in a group.

Divide the students into groups *before* the lesson, by making a roster. Preparing your groupings in advance makes it an accomplished fact. If you make it up as you go, students are more likely to want to argue about their placement.

For most work (microcomputers being an exception), three seems to be a magic number that works better than, say, two or four.

Deciding who to put in which work group is part of the art of teaching. In general, it's a good idea to arrange a mixture of skill levels, as well as levels of understanding, within each group. But there can be other considerations, such as:

- The need to put a new student, or one who has been absent, with some capable peers.
- You may want to form a group entirely composed of individuals who need your personal attention at this time.
- Of course you won't team up students who egg each other on to mischief, whatever the mixture of skills.
- You may have some shy, retiring students in the class who don't contribute when there's a boisterous, take-charge student in their group. It might be wise to make them one group.
- Other things being equal, there is no reason why friends shouldn't be in the same group, and there may be reasons why they should, since people usually pick friends who meet their needs.

A good way of evaluating the quality of a

particular grouping of the class is to ask yourself, "What does this grouping imply about what I'll be doing during this period?" A good grouping permits you to use most of your time productively: teaching those who need your help. A bad grouping will involve you in fighting brushfires all period.

Keep students aware that assignments to groups are temporary, and watch the groups' behavior for signs that a change in grouping is needed. For example, as time passes you may see that students in a particular group are always doing the same jobs: Ann always does the measuring, Bill is always recording the data, and so on. Another sign of a need for immediate change is when one student has been typed by the others as a failure. Changing groupings can give individuals fresh opportunities for growth; see what works.

Organize Equipment and Supplies

One of the biggest differences between teaching through laboratory activities and teaching through reading and discussion is that one has to cope with so much paraphernalia. Your goal should be to shift as much of the responsibility for lab management as you possibly can to students. You can accomplish this by observing the old saw, "A place for everything, and everything in its place."

Basically, there are three schools of thought about how to organize equipment and supplies. Each has its advantages and disadvantages; all are effective in particular classroom situations.

Some teachers like to organize by activity. They put one set of all the materials needed for an activity in a box, with as many boxes as there are working groups of students in a class. A convenient way of enabling students to check that they have received everything that should be in the box, and of remembering from year to year what is needed for each activity, is to make up lists of the materials needed on 3"x5" cards, as many copies as there are boxes, for inclusion in the boxes.

This method makes starting and stopping the activity easy, but it requires a lot of teacher preparation time, since equipment to be reused must be transferred to the next set of boxes after almost every lesson. This method is probably most appropriate in situations in which a large number of classes do the same activity within about the same time period, i.e., for a science center in a large school, or for an enrichment teacher who travels from school to school.

A second method is to organize supplies and equipment by working groups. At the beginning of the semester, each group of students is given a "tool kit," a box containing a comprehensive set of supplies which they will use until the end of the semester, with some occasional supplements of consumables needed for only one lesson. The advantages of this method are that it says very forcefully that the students are responsible for the equipment (students tend to think of it as "our" beaker instead of the school's), it cuts down on prep time, and less classtime is consumed in starting an activity than is used in method three. The disadvantages are that it can make it difficult to verify when or under what circumstances something was lost or broken. Also, students can be distracted by the materials not yet needed. This method is very appropriate where you have a room that will be used only for laboratory activities and groups can have permanent working stations with lockable drawers.

The third method is to arrange all equipment and supplies by type in storage that can be made accessible to the students (though perhaps locked between classes). For example, one box contains Celsius thermometers, another only dropper bottles, and so forth. At the beginning of the lab, one student from each group obtains from the boxes what his or her group needs, and returns the equipment to the boxes at the end of the lab. (The reproducible activity sheets in this book are designed to permit the use of this method.)

To make the third method work, everything must be clearly labeled. Remember that the labels are primarily for the students, not you.

Add drawings of the items to the labels if that is appropriate for your class. Include on every label both the name *and the quantity*. If you have a great many of some particular item, such as thermometers for each of 30 students, make several small boxes rather than one big one. If you have seven thermometers to a box, you can quickly verify the count visually after the lesson. The only way to tell if a box has 30 thermometers is to count them one by one.

Equipment and Demonstrations

Putting out interesting paraphernalia and then insisting on a quarter-hour of seemingly unrelated lecture or discussion before the class gets to do the lab or see the demonstration is a tease. It only tends to make students impatient and irritable.

If the class has finished an investigation and you plan to go on to other work in the same period, have the equipment put away immediately rather than at the end of the period. Materials left out are just a temptation to fiddle.

Establish a routine of having the students put away the equipment and supplies at the completion of the investigation. Plan time for this and ALWAYS INSIST ON IT.

Anticipate Early-Finishers

Have an activity planned for students who finish early. This might be a worksheet, a puzzle, assisting other groups who are having difficulties, or perhaps helping you. This is a good time to make use of more challenging material.

It Isn't the Investigation That Goes Wrong

Keep in mind that demonstrations can fail, but experiments never do, even when the results are not what we expected. Even the "failure" of a demonstration doesn't necessarily mean a teaching failure. What matters is what you do next: grasp the opportunity for investigation and extend an invitation to students to do so also. Why did we get the results we did? On the other hand, rejecting unexpected results is rejecting the principle of experimental inquiry and endorsing an authoritarian, "right answer" view of science, and provides a bad model for students.

Though it may sometimes appear otherwise, your classroom is not a privileged place in which the laws of nature are sometimes suspended.

Craig Inflected Assessment of Parallel Processing

This test will help you and your teacher find out how ready you are to carry out laboratory investigations in science.

You will need a pen or pencil to take the test. Please get one.

Read all the questions before answering any question.

1. In what year were you born? 19 _____
2. Have you previously taken a science course? _____ Yes _____ No
If so, what was its name? _____
3. Knock on your desk with your left hand.
4. Roll your eyes up, to the left, and then to the right. Then immediately make a dot in the exact center of this circle.
5. In a whisper, recite the alphabet backwards, starting with the letter "E."
6. Put a star in the upper right-hand corner of this paper.
7. Label each of these statements T (for True) or F (for False).
Without experiments there would be no science. _____
A person who thinks of a theory should try to think of experiments that would disprove the theory.

Scientific truth is established when all the experts agree on something. _____
8. Write the sum of 56 and 23. _____
9. Moo three times and, at the same, time pat your head with your right hand and pat your stomach with your left hand.
10. The questions above are fake. Do not answer any of them. Simply write your name on the line below and then raise your hand to show that you have finished.

Reproducing the Black-Line Masters

This resource book contains hundreds of pages that can be reproduced for use in the classroom. Several different kinds of pages are included:

Activities. Generally, directions for classroom investigations. In most situations, using such sheets is an improvement on giving only verbal instructions:

- 1) The students have directions to refer to during the activity.
- 2) Students cannot question, after the fact, what directions were given.
- 3) It is less likely some step will be inadvertently left out.
- 4) It is good practice in reading for meaning.
- 5) The consistent format from investigation to investigation becomes familiar and helps allay some students' fears of investigations.

Activity sheets are not meant to be written upon by the students. To keep down costs of copying you may want to collect them for re-use. However, there may be advantages to allowing students, especially slower students, to make notes on the sheets and to keep them as part of a cumulative record of work done.

Readings. Almost all of these are primary source materials that give students a chance to experience how historians try to arrive at the truth. On a more concrete level, other readings provide vicarious experiences of how Americans in earlier times conducted their daily lives and obtained what they needed to live. A number touch upon the interaction between science and technology, and society. Reading levels vary from fifth grade to the point at which reading level is meaningless and the document must be deciphered.

Like activity sheets, readings must be collected for re-use.

Worksheets. Provide a place for recording data from investigations and coach students as to the mathematical operations to be performed.

Worksheets **are** to be written upon by students, and so copies should be considered consumables.

Overheads. Graphs, diagrams, or tables of statistics that can be made into overhead transparencies. If you do not have an overhead projector, some of the pages may be made into handouts that may be collected for re-use. However, it is much harder to focus the students' attention with handouts than it is with the overhead projector.

Helpsheets. This is an experimental feature. It provides directions to adult volunteers working independently. Because, at most, only one or two copies are required, photocopying is the most sensible way to reproduce these sheets.

Many teachers have asked that we provide the reproducible pages in the form of spirit masters. Unfortunately, the cost of doing so is prohibitive—and after making 100 copies, the teacher would still be faced with the problem of making new masters. We feel the black-line master method provides the best balance between convenience and the greatest help to the greatest number of teachers.

How to Make Copies

A school that is fortunate enough to have a photocopier, such as a Xerox® machine, can use it to prepare both paper copies and overhead transparencies. The following information is for schools using spirit duplicators (such as the Ditto® machine) or mimeographs.

To Make Spirit Masters

To make spirit masters directly from the printed pages, you will need an infrared copying machine (such as a Thermofax®). Many schools have these machines, sometimes sitting in storage unused. (If an old machine doesn't work, the most likely cause is a broken or bad rubber belt, which you can replace yourself. The 3M company sells replacement belts for around \$21.)

If the school doesn't already own a Thermofax, and a number of teachers would like to make spirit masters, investigate the used office-equipment market. Many used thermal copiers became available when the photocopy machines became popular.

You will also need 8½" x 11" *3M Brand Thermal Spirit Masters*. (Around \$10 for a box of a hundred masters.) If you cannot find a local dealer, look under 3M in the phone book or call 3M at 800-328-1371. Directions are packaged with the masters; all that is required is to feed the original and the master into the machine.

The prepared masters are used just as you would a master you had typed or drawn by hand. Each master will make about one hundred copies.

To Make Mimeograph Stencils

There are two methods of making stencil masters. If you have an infrared copying machine, you can use *3M Brand Thermal Stencil Masters* at around \$44.95 for a box of 100. These stencils are good for about 1000 copies. Alternatively, a large school may be able to afford a machine like the Gestefax®, which scans pages and cuts stencils electronically.

To Make Overhead Transparencies

Pages can be copied onto clear plastic film by an electrostatic photocopying machine (such as a Xerox) or by an infrared copy machine. In either case, we recommend that you use the heaviest weight of film that is obtainable. The lighter gauges tend to wrinkle, making it impossible to bring all of the image into focus at one time.

For infrared copy machines, we recommend *3M Brand Transparency Film Type 570*. This type is around \$47 for a box of 100 sheets (compared to \$30 for the lighter type 137), but we think the extra money is well spent, especially if you expect to use the transparencies for several years.

Many good brands of transparency film are available for electrostatic photocopy machines, but what works on one machine may not work well on another. Films that are completely clear will not work at all on machines that use a light sensor to detect the position of the paper. Transparency films for such machines must have an opaque stripe along the proper edge.

Materials supplied by the maker of the machine are most likely to be satisfactory.

Index and Glossary

This index is intended to meet the diverse needs of several types of users:

- 1) The teacher who is seeking lesson plans, activities or readings that correspond with key concepts or topics from his or her textbook or syllabus.
- 2) The teacher who has used an activity or reading and remembers the content but not the location of the lesson.
- 3) The teacher who is seeking a brief explanation (not simply a definition) of an important or unusual energy-related word. If the explanation here is not sufficient, the *McGraw-Hill Encyclopedia of Science and Technology* is an excellent source for fuller discussions.

This Index and Glossary is not intended for student use.

To make it easier for the history teacher to notice historical material, such items are marked 1600s, 1700s, etc.

Key to Abbreviations

6-33 = page 33 of Unit 6. Units 1 and 2 are in Volume 2; units 3 through 8 are in Volume 3.

5-27ff = see page 5-27 but also the pages following it.

SB-3 = page 3 of the Student Booklet, that is, **Energy 83**. When referred to the student booklet, please also consult the corresponding pages in the **Teachers Guide to the Energy 83 Student Booklet**.

q.v. = which see; indicates that the word or phase is also listed in the Index and Glossary.

A

absolute zero *The temperature at which, if gases behaved the same way at all temperatures, a gas would have no pressure, and molecular motion would stop. About -273.15° Celsius.* 1-173

absorptance *In solar collectors, the ratio of the amount of light absorbed by a surface to the amount of light striking the surface. A black surface, for example, will have a much higher absorptance than a white one.*

active solar system *A heating system that uses sunlight as the main source of heat, and actively transfers this heat between collector, storage, and living area by means of pumps or fans. The pumps and fans employ an energy source other than sunlight, typically electricity. Compare **passive solar system**.* 5-5

agriculture, energy in SB-9, 2-55

alpha particle *A group of two neutrons and two protons (equivalent to a helium) thrown off in the decay of some radioactive atoms or in other nuclear reactions.* SB-18

altitude *The angle, measured in a vertical plane, between the horizon and the line of sight to an object. Together with the azimuth or bearing angle, used to describe the position of an object in the heavens, such as the sun (solar altitude). measuring altitude of sun, 5-22*

ampere 1-82, 1-89
finding, 1-93

AMU *A unit of mass equal to one-twelfth of the mass of the carbon atom of mass number 12.* 4-21ff.

anaerobic fermentation *Decomposition of biomass by organisms that do not require an atmosphere of oxygen. See **methane**.*

angle of incidence *The angle at which a beam of radiation arrives at a surface, measured from a line at right angles to the surface (the normal) at the point where the beam strikes the surface.*

anthracite *Coal that consists almost entirely of carbon, the result of having been subjected to intense heat and pressure in the earth. Often called "hard coal" in the United States.*

armature *The part of an electric motor that rotates.* 1-25

astrolabe 5-15

Astronomer to the Pharaoh certificate 5-34

atom SB-18, 4-5

atomic (distinction between "atomic" and "nuclear") 4-3

atomic number *The number of protons in the nucleus of an atom.*

automation 6-51

automobile SB-16

available work The maximum amount of work that can be obtained from a system (or a fuel) as it proceeds by any path to a specified final state in thermodynamic equilibrium with the atmosphere.

B

background radiation Ionizing radiation from the decay of radioactive atoms naturally present in the environment, and from cosmic rays.

bag house In a coal-burning electric power plant, an air pollution control device in which the stack gases are filtered through bags, typically made of fiberglass, in order to remove solid particles of ash.

barrel In measuring petroleum, 42 American gallons. This measurement evolved from the capacity of the wooden barrels used in the first oil fields in Pennsylvania.

base load The least amount of energy demanded by the customers of a gas or electric utility during a given period of time. Since the base load is demanded constantly, it can be provided by whatever means has the lowest cost per unit output, even if the output is not easily adjustable to follow changes in demand.

batteries (electric) 1-41

student construction of, 1-46

diagrams of, 1-44, 1-45

bearing The angle between true north and the line of sight to an object, measured in a horizontal plane clockwise from north.
worksheet, 5-13

beta particle An electron (either positively or negatively charged) traveling at a high velocity, thrown off in the decay of a radioactive nucleus or in another nuclear reaction.

bills (utility) 1-105ff

reading electric, 1-109

reading gas, 1-113

biofuel Biomass that can be burned as a fuel, such as firewood.

biomass The organic mass of living things. 5-57

bitumen Substances found in the earth (often spread through a rock), chiefly made of carbon and hydrogen, and soluble in such solvents as carbon disulphide.

bituminous coal A type of coal high in volatiles. Often called "soft coal" in the United States.
activity, 3-10

black body An imaginary "perfect" absorber and emitter of radiation. It would absorb all radiation falling upon it.

blowout An accident in which control is lost over the flow of petroleum from a gas or oil well.

boiling water reactor A type of light-water reactor in which the water in the heat exchange loop passing through the reactor core is allowed to boil—one of the two types of light-water reactors in common use in the United States.

breeder reactor A type of nuclear reactor designed to promote conversion of nuclei that cannot be made to fission by thermal neutrons (a property that is required if they are to be used as fuel in a reactor) into nuclei that can. This is done by producing (by fission) more neutrons than are needed to sustain the chain reaction. Excess neutrons striking uranium-238 nuclei convert them (ultimately) to plutonium-239. Thorium can be converted to uranium-233.

British thermal unit See Btu.

Btu The quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit, at or near its point of maximum density (39.1°F). Burning one wooden kitchen match releases about one Btu. 1-63ff

bumblebees (energy flow in the economy of) 2-51

BWR See boiling water reactor.

C

calorie The quantity of energy required to raise the temperature of one gram of water one degree Celsius, at 15°C.
defined, 1-51ff

Calorie (food Calorie, kilocalorie) = 1000 calories.
2-43, 2-48, 4-25

calorimeter (student activity) 2-47ff

candlemaking 6-40

capacity (of power plants) The amount of electricity the plant was designed to produce; its rated output.

capacity factor The ratio of the amount of electrical energy actually supplied by a power plant to the amount it could have supplied in the same period of time had it been operated at its rated output.

capital

defined, 7-29

substitution of capital for labor, 6-51ff, 7-39ff

carbohydrate Compounds composed of carbon, hydrogen, and oxygen, with the formula $(CH_2O)_n$, where n is four or more.

as a product of photosynthesis, SB-8&9

carbon dioxide

as an input in photosynthesis, SB-8&9, 2-33

student investigation of as a product of respiration, 2-39

as a combustion-created pollutant (greenhouse effect), SB-13

catagenesis The process by which the organic materials in sediments are changed by being heated within the earth, at temperatures be-

between 50°C and 200°C. Compare **diagenesis**.

catalyst A substance that promotes a chemical reaction without itself contributing atoms to the products of the reaction. Chlorophyll is an example of a catalyst in nature. Catalysts are very important in oil refining (catalytic cracking), pollution control (the catalytic converter on automobiles), and petrochemical processes.

caulk An adhesive, gap-filling substance used to fill holes in the envelope of a building. economics of, SB-30&31 home audit to determine need for, SB-39

chlorophyll SB-8&9, 2-21f

chromatography 2-23

cladding In nuclear reactors, the material that surrounds and holds the fuel. In many reactors, the fuel is in the form of rods, and the cladding is a zirconium alloy in the form of a can.

coal
and the Industrial Revolution, SB-12&13
formation, SB-10
pollution created by combustion of, 3-9ff
transition from wood to coal in U.S., SB-12, 3-17, 3-19, 6-31
transition from coal to gas in U.S., 3-17ff

coal gasification Conversion of coal to a fuel gas. Older processes either left most of the carbon as a residue (coal gas) or produced largely carbon monoxide or hydrogen (water gas, producer gas). All had a much lower heating value than natural gas. Newer processes (like the Lurgi) start with the products of the old and go on to produce methane.

coal liquefaction Conversion of coal (by adding hydrogen atoms) to liquid hydrocarbons for use as a fuel, such as synthetic gasoline.

coal stoves 3-19

coefficient of performance (COP) In heat pumps, the ratio of the energy supplied as heat by the heat pump to the energy supplied to the heat pump in the form of electricity (or, sometimes, natural gas). A measure of the "efficiency" of heat pumps; but COPs are usually in the range of 200% to 300%. The COP can be more than 100% because the heat extracted from the air or water is not considered an input.

cogeneration Generating electricity (typically by burning gas in a turbine) while using the waste heat for space heating or industrial processes.

combined cycle A combination of a gas turbine and a steam turbine in an electrical generating plant. The hot gases coming from the gas turbine are used to make steam to run the steam turbine.

commutator A part of an electric motor that acts as a switch reversing the flow of current depending upon the position of the armature. 1-25

condensation The change from a gas or vapor to a liquid. The thermal energy absorbed when a liquid evaporates is released when it condenses.

conduction (of heat) A process of heat transfer by molecules imparting a portion of their kinetic energy to adjacent molecules.

conservation of energy, law of See **thermodynamics, first law of**.

conservation of energy (saving energy) See also **efficiency**.
lighting, SB 34, 1-149ff
laundry, SB-34&35, SB-44
recycling as a form of, SB-35, 7-65ff
heating and cooling, SB-36ff
water heating SB-44, 1-115, 1-160

consumer (in food chains) An organism that obtains its energy by eating other organisms. Consumers may be secondary consumers, tertiary consumers, etc., depending on how many organisms removed they are from the producer.

containment In nucleus power plants, the separation of the reactor proper and its supporting equipment from the outside world; also, the structures designed to achieve this.

control rod A device inserted into the core of a nuclear reactor to slow or stop a chain reaction by absorbing the neutrons needed to make nuclei fission. Control rods are made of substances like boron that are especially strong absorbers of neutrons.

convection The transfer of heat by means of moving currents of a fluid set in motion by density differences caused by temperature differences. One of the three means by which heat is transferred, the others being **conduction** and **radiation**. 2-8

conversion factors 1-137

cooling degree day A measure of the demand for air conditioning created by the weather, found by subtracting the average of the maximum and minimum temperatures (in degrees Fahrenheit) on that day from 75°F. Cooling degree days are not as good a predictor of the demand for energy as **heating degree days** are.

COP See **coefficient of performance**.

cord A measurement of a quantity of wood: a stack of wood 4 feet by 4 feet by 8 feet. A face cord is 4 feet high and 8 feet long, but may be any depth.

core In nuclear reactors, the part of the reactor in which fuel fissions, producing thermal energy.

cracking In oil refining, a process that breaks large molecules down into smaller, more desirable ones, such as those included in gasoline.

criticality In nuclear reactors, the state in which the number of neutrons in flight remains approximately constant because neutrons are being produced by fission as fast as they are being absorbed.

critical mass The smallest amount of a fissionable substance in which a self-sustaining chain reaction can take place.

crude oil Petroleum that is removed from the earth as a liquid (or could be).
reserves, SB-15, 3-39ff
world trade in, SB-32&33

D

decay, radioactive The transformation of a nucleus into a nucleus of another type of atom, with the emission of radiation. SB-18

decomposers In a food web, the bacteria and fungi that break down dead biomass and release its chemical components.

degree day See **heating degree day** or **cooling degree day**.

degrees Kelvin See **Kelvin scale**.

demand One side of the market: what and how much buyers are willing and able to buy, as opposed to **supply**. Also, the quantity of a good or service buyers are willing and able to buy at a given price.

depletion of resources 3-45

development well A well drilled to extract oil or gas from a field that has already produced oil or gas.

diagenesis In petroleum formation, the process by which the organic debris in sediments is altered without much effect from rising temperature.

double-glazed Covered by two panes of glass or plastic separated by an air space (of windows or solar collectors).

doubling time The amount of time required for an exponentially increasing quantity to double; a way of stating a rate of **exponential growth**. For example, a doubling time of 2 years corresponds to an annual growth rate of 41.4%.

drag (on automobiles) The retarding force acting on an automobile due to the air through which it is moving.

E

EER Energy Efficiency Ratio. A rating of the efficiency of air conditioners, found by dividing the air conditioner's capacity in Btu per hour by the unit's wattage. See also **SEER**.

efficiency
defined, SB-4&5, 1-141ff
efficiency of hot plate-pot system, student investigation of, 1-147
of electric lights, 1-149ff
of Franklin stove, 6-14
second-law efficiency, 1-179ff

elasticity of demand, price In economics, the extent to which the quantity demanded depends on the market price, all other things being equal.
$$E = \frac{\text{percentage change in quantity purchased}}{\text{percentage change in price}}$$

Short-term elasticity of demand for a good may be quite different from its long-term elasticity (It takes a while to reduce your gasoline consumption by moving to a home nearer your job.)

elasticity of supply, price In economics, the extent to which the quantity sellers are willing and able to supply depends on the market price, all other things being equal. Short-term elasticity of supply for a good may be quite different from its long-term elasticity. (It takes a while to develop new oil fields.)

electric generator 1-19

electrical energy
changed to chemical energy 1-47ff
changed to light, SB-4&5, 115ff
changed to motion, 1-19ff, 1-23ff
measuring, 1-83 through 1-101
produced from light, see **photovoltaic cell**.
electric charge 4-3

electrolysis of water 1-47ff.

electromagnet 1-25
student construction of, 1-27

embodied energy The energy consumed in providing goods and services to the end user (for example the energy used to manufacture and transport a washing machine) as distinct from the energy consumed by the purchaser in the course of using that good or service (the purchaser's utility bills). 7-66ff.

energy
flows, SB-2 through SB-11, 1-161
forms, SB-2&3, 1-11
conversions:
changed to electricity, 1-131
chemical to electrical, 1-41
electrical to chemical, 1-47
motion to thermal, 1-67

enhanced recovery of petroleum *Production of petroleum from a depleted field. See secondary recovery of petroleum and tertiary recovery of petroleum.*

enrichment *The part of the nuclear cycle in which the percentage of the uranium that is U-235 is increased from the less than 1% in ore to 3% or more.*

equilibrium price *See market-clearing price.*

evaporation 2-11

exponential growth *Growth such that the quantity at the end of a given period of time can be described by a fixed number times the quantity at the beginning. The growth of money in a savings account is an example of exponential growth. As opposed to arithmetic growth, in which the quantity at the end of each period will be the quantity at the beginning plus some fixed amount. The growth of money in a piggy bank to which a fixed allowance is added each week is an example of arithmetic growth.*

external cost *A cost involved in the production or consumption of a good or service which is not borne by the producer or consumer. Costs created by pollution are a typical external cost. 7-49ff*

externalities *See external cost.*

F

factors of production *In economics, the three necessities for production of goods: capital, labor, and natural resources. 7-29, 7-35*

fertile material *A material that is not fissioned by thermal neutrons (and so cannot be used as a fuel in a reactor), but which can be changed to a fissionable material by being bombarded by neutrons. For example, uranium-238 is not fissionable, but it can be converted to plutonium-239. Therefore it is fertile.*

finding & development costs (for oil) 7-25

fissile (of isotopes) *Capable of being fissioned by a thermal neutron.*

fission *See nuclear fission.*

fizzle *A nuclear explosion in which the critical mass of fissioning material is blown apart as the reaction begins, thus aborting the reaction before an atom bomb type explosion can occur. (In a bomb, elaborate provisions are made to keep the materials together.) Some accidents connected with the military use of nuclear energy have involved fizzles.*

fluidized bed combustion *A way of burning a solid fuel, such as coal, in a bed consisting of fine particles of fuel and other materials. The particles are supported and kept separated by gases blown through the bed. The gas separating the particles lets the material flow like a liquid. Combustion is almost complete and it is possible to introduce various anti-pollution measures; for example, to involve sulphur atoms in reactions that prevent their getting into the flue gases.*

fly ash *Very tiny, solid, noncombustible particles carried by the flue gases produced by burning (typically) coal.*

food chain SB-8&9

food

energy content, student investigation of, 2-50
preservation 6-7, 6-29, 6-43ff, 6-61

food system, U.S. (energy inputs other than sunlight) SB-7, 2-54, 2-55

food web SB-8&9, 2-49

force 1-79ff

Franklin, Benjamin (advantages of the Franklin stove, 1700s) 6-13

fuel (defined) 3-5

fuel cell *A device that produces electrical energy directly from a chemical reaction in which a fuel, such as natural gas, is oxidized.*

fusion SB-19

G

gamma rays *A type of very high frequency, very energetic radiation. Gamma rays are emitted when some radioactive atoms decay.*

gas, natural

first gas utility in U.S., 6-19

lights, 6-19

reading gas bills, 1-113

reading gas meters, 1-111

stoves, 2-20

transition from coal to gas, SB-16, 3-17ff

gasohol *A mixture of gasoline and alcohol, usually ethanol, used as motor fuel. In Nebraska, Gasohol is a trademark.*

gasoline *The fraction of crude petroleum that boils between about 15°C and 200°C. 3-25, 3-28*

Maxim's experiments with gasoline, 3-25

geothermal energy *The heat within the earth, evident in geysers, hot springs, and volcanoes. Most of this energy comes from the decay of radioactive materials in the earth's crust. SB-21*

gray *The SI unit of absorbed dose, equal to 100 rad. Not yet in general use.*

greenhouse effect Increase in the temperature of an absorber due to its being covered with a material that permits passage of light at the wavelengths of the incoming radiation, but that retards the escape of radiation at the wavelengths given off by the absorber. The temperature of the earth's surface depends on this effect because, although the atmosphere is transparent to visible light, it is a good absorber of the infrared emitted by the warm earth. Of interest because as fossil fuel combustion increases the percentage of carbon dioxide in the atmosphere, the atmosphere will become an even better absorber of infrared, raising the temperature of the earth's surface. A misnomer, because the primary means by which greenhouses retain heat is the suppression of convection.

H

half-life (of radioactive isotopes) The time required for half the atoms in any quantity of a given radioactive isotope to change to another isotope.
student simulation of, 4-13

heat A form of energy that is transferred between objects solely because of a difference in their temperatures. Heat is the disorderly and work the orderly form of energy-in-transit.
1-51ff
as energy-in-transit, 1-50

heat engine A device for converting heat to work.
1-167ff, 1-171ff

heat exchanger A device for facilitating the transfer of heat from one stream of fluid to another. Nuclear power plants, tightly sealed houses, and active solar systems all employ heat exchangers.

heat pump A device that uses work to transfer heat from a cold place to a hot place.

heating degree day A measure of the demand for comfort heating created by climate or weather. The number of heating degree days for a particular day is found by subtracting the average of the maximum and minimum temperatures from 65°F. SB-36

high-temperature gas-cooled reactor A reactor that uses graphite as a moderator and helium as a heat-transfer fluid.

horse 6-46

horsepower A customary unit for measuring power.

horsepower-hour A customary unit for measuring energy; the equivalent of energy used at the rate of one horsepower for one hour.

hot-dog cooker 5-41ff

HTGR See high-temperature gas-cooled reactor.

hydrocarbon A chemical compound consisting primarily of hydrogen and carbon atoms.

ice cutting 6-43

incandescence 1-16

indirect energy 7-66

indoor air pollution SB-39

infiltration The uncontrolled movement of air in and out of a building, through such cracks as those around closed windows and doors and between the siding and the foundation. Strictly speaking, the loss of air should be called exfiltration. SB-38&39

insolation The amount of radiation received from the sun per unit area.

insulation In construction, building material used to slow the flow of heat. Most forms of insulation are means of trapping air. Strictly speaking, the word should be qualified to indicate what sort of flow is being resisted, i.e., thermal insulation as distinct from electrical insulation.

insulator, electrical 1-42

internal combustion engine 1-167, 3-25ff, 3-29ff

iodine (as a starch detector) 2-27

isotope 4-13

chart, 4-9

J

joule The basic SI unit of energy. It is equal to the energy newton-meter, or one watt-second.
1-52, 1-81

K

Kalm, Pehr (firewood supply in Philadelphia, petroleum, 1700s) 6-17

Kelvin scale A temperature scale in which zero is set at absolute zero, -273.15°C, and the size of the degree is the same as in the Celsius scale. To convert degrees Celsius to Kelvin, add 273.15. (The word "degree" is not used between the number and "Kelvin"; i.e., 15 Kelvin, not 15 degrees Kelvin.)

kerogen The organic material, not yet altered by heating, which is spread throughout a sedimentary rock. Heating converts kerogen to gas, or gas and oil. Kerogen cannot be dissolved by nonoxidizing acids, bases, or organic solvents. The "oil" in oil shale is kerogen.

kerosene The part of crude petroleum that boils between about 200°C and 260°C.
as most-sought petroleum product, 1800s
SB-14

risk of explosions in lamps, 1800s 6-35, 6-65

kilo- Prefix meaning 1000. For kilocalorie, kilowatt, etc., see under calorie, watt, etc.

kinetic energy The energy a body possesses by virtue of its motion.
SB-2&3, 1-52

L

- labor** One of the three factors of production. 7-29ff, 7-35ff, 7-39ff
- langley** A unit used to measure insolation, equal to one calorie per square centimeter per second.
- lead time** (required to construct large energy supply projects) 6-69ff
- life-cycle costing** A means of evaluating the total cost of the purchase and use of a good, by totaling the **present value** of all costs incurred over the lifetime of the investment. For example, the life-cycle cost of an automobile would be found by adding the present value of its purchase price, salvage value, all fuel bought during its lifetime, maintenance costs, and so on.
- light, artificial**
candlemaking, 1800s, 6-40
efficiency of incandescent and fluorescent compared, 1-152
electric:
 lightbulb, student construction of, 1-15
 impact of introduction of, 1800s, 6-67
 gas lights, 6-19
 kerosene, SB-16, 6-35, 6-65
- light** (as a form of energy) 1-15
 changing light to electricity, 1-31
 changing light to motion, 1-37
- light bulb**
 diagram, 1-18
 student construction of, 1-17
- light-water reactor** A nuclear reactor in which ordinary water is used to slow down the neutrons (as moderator) and also to transfer heat from the core (as coolant). In contrast, a heavy-water reactor uses water whose hydrogen atoms are the isotope deuterium, the isotope of hydrogen with a neutron. SB-19
- lignite** A low-grade form of coal.
- LNG** Liquefied Natural Gas. Natural gas cooled to -259°F, at which point it becomes a liquid with about 1/600th its original volume.
- load management** The effort by gas and electric utilities to make the amount of energy demanded (the load) more nearly the same at various times of day. This is often done by providing incentives for customers to reduce consumption during the hours when the greatest amount of electricity is being demanded.
- LWR** See light-water reactor.

M

- magnetism** 1-19ff
- marginal cost** The cost of producing or purchasing the last (or one more) unit, as distinct from the average cost.
- market-clearing price** The price at which buyers are willing and able to buy all of a good or service which suppliers are willing and able to sell. At prices above the market-clearing price, some would-be sellers will not find buyers. At prices below the market-clearing price, some would-be buyers will not find sellers. The supply curve crosses the demand curve at the market clearing price.
- Maxim, Hiram Percy** (gasoline as a fuel for internal combustion engines, 1800s) 3-25
- mechanical energy** 1-67
 measuring, 1-79
- meters, utility**
 reading electric meters, 1-95ff
 reading gas meters, 1-111
- methane** A chemical compound whose molecules consist of one carbon atom and four hydrogen atoms (CH_4). The principal component of natural gas.
 production by anaerobic digestion, 5-57ff
- milli-** SI prefix meaning one-thousandth. See **liter, rad, rem**, etc., for the meaning of the root.
- milling** (in the uranium fuel cycle) The step in which uranium oxide is extracted from ore (which is typically about 0.2% uranium oxide) and concentrated to produce a material called yellowcake, which is 80%-90% uranium oxide.
- moderator** The substance in a nuclear reactor that is used to slow down the fast-moving neutrons produced by fission so that they will stay in the fuel longer and be more likely to cause a nucleus to fission.
- motor** 1-19, 1-23
 student construction of, 1-27
- motor, electric** 1-19, 1-23
 student construction of, 1-27
- Mylar**, aluminized 5-36

N

natural gas A kind of petroleum consisting mostly of gaseous hydrocarbons like methane, ethane, and propane, sometimes with liquid hydrocarbons, and often containing non-hydrocarbons like carbon dioxide and helium. Marketed natural gas is almost entirely methane.

natural resources

factor of production, 7-30

neutron One of the atomic particles found in the nucleus of an atom. It has the mass of a proton and no electric charge.

newton The SI unit of force. 1-80

nuclear energy SB-18&19, Unit 4

nuclear fission 4-21

nuclear power reactor SB-19

nucleus (of an atom) 4-3

O

oil shale A type of rock that yields oil when it is destructively distilled. Vast deposits are found in Wyoming and Colorado. (The term is a misnomer, since it isn't shale and the organic material present in the rock is not oil. Destructive distillation takes the place of catagenesis.)

OPEC The Organization of Petroleum Exporting Countries. Not all oil exporting countries are members of the organization (e.g., Canada, Mexico, Great Britain, Norway) and not all members are Arab.

opportunity cost The cost of giving up the next-best choice. 7-29ff, 7-35ff

overburden The soil and rock lying above a seam of valuable mineral or ore.

oxygen 2-29

P

parabola A curve in a plane such that every point on the curve is equally distant from a fixed point and a fixed line; one of the conic sections. A bowl-shaped mirror in the shape of a parabola rotated about its axis will reflect all light rays parallel to the axis to a focus point. (Most flashlights contain such a mirror.) A trough-shaped mirror whose cross section is a parabola will reflect the rays to a line. 5-38, 5-39, 5-47

methods of constructing a parabola, 5-50ff

particulates Microscopic solid particles that are a major type of air pollutant.

passive solar system A heating system whose energy source is sunlight, and which employs little or no additional energy from other sources, in contrast to an active solar system. In a passive system, if heat is referred by circulating fluids, they are driven by convection alone (thermosiphoning).

peak load The maximum amount of energy demanded of a distribution system within a given period of time.

permeability The extent to which a rock permits fluid to flow through it.

perpetual motion machines 1-38, 1-16ff

petroleum A kind of bitumen that is liquid or gaseous in its natural reservoir.

discovery of:

American colonies, 1700s, 6-18

Drake's Well, SB-16

extraction, 3-13

reserves and resources, SB-16 & 17, 3-39ff, 3-45ff

phase change material A substance used to store energy through a change of phase, usually from solid to liquid. When a substance changes a solid to a liquid, it absorbs energy. When the liquid freezes, an equivalent amount of thermal energy is released.

photosynthesis SB-8 & 9, 2-25ff, 2-29ff

Pliny the Elder 1st Century A. D. 3-6

plowing 6-47

pore In geology, small holes within rocks. Larger holes are called vugs.

porosity The capacity of a rock to hold a fluid, such as water, gas, or crude oil, within its pores. Compare permeability.

potential energy The energy a body possesses because of its position. In contrast to kinetic energy, which is the energy a body possesses by virtue of its motion.

power The rate at which energy is used. The horsepower of a motor and the wattage of an electric device or measurements of power, in contrast to horsepower-hours and watt-hours, which are measurements of a quantity of energy.

present value The value today of an amount to be received or spent in the future.

pressurized water reactor A light-water reactor in which the water passing through the reactor core is kept under high pressure to prevent it from boiling, and the heat from that pressurized water is used in a heat exchanger to generate steam in another loop in order to drive a turbine.

price controls Laws that establish a maximum or minimum lawful price for which something can be sold.

process heat Heat needed to carry on an industrial process, in contrast to comfort heat.

process steam Steam raised to be used as an input to a process, in contrast to steam raised to drive a turbine or to heat something.

producer 1) a person, company, or government who extracts oil or gas 2) an organism that requires no organic inputs. Almost all producers are green plants that capture the energy of sunlight through photosynthesis, but a bacteria that exists on hydrogen sulfide in a hot spring is also a producer. All food chains begin with producers.

productivity 7-39

proton An atomic particle with a positive charge equal to the electron's negative charge but with a mass of 1,847 electrons. 4-3

PWR See **pressurized water reactor**.

Q

quad A unit equal to one quadrillion (1,000,000,000,000,000 or 10^{15}) Btu. In the United States, energy supply and use on a national scale are usually discussed in terms of quads. table of equivalents, 1-138

R

rad (From Radiation Absorbed Dose.) A unit of dosage of radiation: the amount of radiation that transfers 100 ergs of energy to each gram of soft tissue.

radiation Energy propagated as waves. Radio and television broad casts, microwaves, infrared, visible light, ultraviolet, X rays, and gamma rays are all forms of radiation, differing in the frequencies of their waves.

radioactivity The transformation of a nucleus into a nucleus of another type, accompanied by the emission of energetic particles and radiation. SB-18 & 19, 4-13

radiometer 1-37

railroads (effect on development of U. S. coal resources) SB-14

refrigeration

ice cutting, 1800s, 6-43

rem (From Roentgen Equivalent Man.) A unit used to measure a dose of radiation in terms of its effect on living things. For gamma rays, 1 rem is the amount of radiation that transfers 60,000,000 million electron volts (MeV) of energy on each gram of biological tissue. For other kinds of radiation, it is the amount of radiation that the same amount of biological damage as 1 rem of gamma rays. Usually measurements are given in millirem (one thousandth of a rem).

reservoir rock The rock in which a deposit of petroleum is found.

reserves The amount of a mineral or ore in deposits whose locations are known and which would not cost more to extract than the mineral currently sells for (economically recoverable using existing technology).

resources The amount of a mineral or ore that is inferred to exist in the earth from geological evidence, including deposits whose existence may not have been demonstrated by sampling and/or which may not be economically or technically extractable at the present time. As distinct from **reserves**.

respiration SB-7

of seeds, 2-38

of students before and after exertion, 2-33

R-value A measure of the Resistance of building materials to the flow of heat. A material with an R-value of 1 will permit the passage of 1 Btu through an area of 1 square foot in 1 hour when the temperatures on the two sides of the wall differ by 1 degree Fahrenheit.

$$R\text{-value} = \frac{\text{hrs.} \times \text{area in sq. ft.} \times \text{temp. difference in } ^\circ\text{F}}{\text{heat transferred in Btu}}$$

S

scrubber A device that uses a spray of liquid to remove pollutants from a flow of gas, usually sulphur dioxide from stack gases created by combustion.

secondary recovery of petroleum Enhanced recovery of petroleum (q.v.) by forcing carbon dioxide, natural gas, or water into the reservoir rock.

SEER Seasonal Energy Efficiency Ratio.

selective surface In solar collectors, a surface that is a good absorber of sunlight but a poor emitter of light at the wavelengths emitted by bodies at the temperatures reached by collector plates.

severance tax A tax levied on minerals at the time they are mined. A number of states, including Montana and Wyoming, have such taxes.

SI Systeme International, the newly revised international system of units, often referred to as the "metric system."

sievert The SI unit of dose equivalent, equal to one joule per kilogram (which is 100 rem). This unit is not yet in very widespread use.

sink The lower-temperature reservoir toward which heat flows in the operation of, for example, a heat engine. In most devices the atmosphere acts as the sink. Compare **source**. 1-57

slurry pipeline A pipeline in which a solid material, such as coal, is pumped as a powder mixed with a liquid like water.

Smith, Captain John (list of things to bring to the New World, 1600s) 6-7

social cost The costs incurred by society as a whole as a result of an action, in contrast to the costs incurred by the participants. See **external costs**

soft path A term coined by Amory Lovins to describe a projected energy delivery system which would be characterized by reliance on renewable sources, diversity and decentralization of energy supply, the use of easy-to-understand technologies, and matching energy in scale and energy quality to the end use. In contrast to "hard path," supposed by Lovins to require centralized delivery systems, reliance on fossil fuels and nuclear energy, and extensive use of high-quality energy sources for low-quality uses.

solar access Having an unobstructed, direct line of sight to the sun's path.

solar cells 1-34

solar rotisserie 5-41

source rock A fine-grained sediment that has released enough hydrocarbons to create an oil or gas deposit.

solar collector

concentrating collector, 5-38

parabolic cooker, 5-41

solar energy

in nature, Unit 2

technology of, Unit 5

source The higher temperature reservoir from which heat flows in the operation of, for example, a heat engine. Compare **sink**. 1-57

spot market A market in which oil is sold "on the spot." About 95% of all crude oil is sold under long-term contracts which set a price for a number of years. Thus prices change slowly, as contracts expire and new ones are written. In the spot market, centered in Rotterdam, crude oil can be purchased in small quantities for immediate delivery—by the tankerful, for example—at whatever price the buyer and seller agree on at that moment. Prices on the spot market influence the prices agreed on in the long-term contracts.

steam engines 3-30

starch (as evidence of photosynthesis) 2-25

stomata Small openings in the surface of a leaf, through which the plant exchanges oxygen and carbon dioxide with the atmosphere.

stoves 6-13

coal, 1800s, 3-19

gas, 1800s, 3-20

strip mining A type of surface-mining in which the overburden is removed in parallel strips. **stud** In conventional house framing, the vertical 2x4s in walls.

sulphur (as a pollutant-creating impurity in coal) SB-15

sun

apparent movement of, 5-9ff

as nuclear reactor, SB-6&7

supply One side of the market: what and how much sellers are willing and able to sell, as opposed to **demand**. Also, the quantity of a good or service sellers are willing and able to sell at a given price.

effect of changes in supply schedule:

fuelwood in Philadelphia, 1700s, 6-17

surface-mining A type of mining in which the undesired material over a seam of mineral or ore (the **overburden**) is removed to expose the material to be mined (in contrast to underground mining). Where the location of the seam makes it economically feasible, the advantages of surface-mining are that it recovers a greater portion of the deposit, and is safer.

synfuel See **synthetic fuel**.

synthetic fuel A man-made fuel.

T

tailings Wastes left from a separation process such as uranium milling.

tar sands Sand saturated with heavy oil. There is a very large deposit in Athabaska in Canada. (This term is a misnomer; tar is a manufactured product made by distilling coal, wood, etc.)

temperature A measure of the average random velocity of the molecules in a body.

tertiary recovery of petroleum Enhanced recovery of petroleum by such means as heating the deposit with injected steam, injecting detergents to scrub additional oil from the pores.

therm A quantity of natural gas with a heating value of 100,000 Btu. This unit is used by utilities in billing customers for gas.

thermal energy The energy of the random motion of the molecules of a mass. 1-50

produced by friction, 1-67ff

produced by the absorption of light, 5-5ff, 5-35ff

thermal mass A quantity of masonry, water or other material included in a building for its moderating effect on temperature.

thermal neutron A neutron traveling at about the same velocity as the other particles around it (due to their thermal energy), as opposed to one traveling with higher velocities of neutrons ejected from a fission reaction.

- thermodynamics, first law of** Energy can neither be created or destroyed. SB-2&3, 1-32, 1-139
- thermodynamics, second law of** 1-139, 1-161ff
- thermopile** A device consisting of a series of thermocouples, each of which is a junction of dissimilar conductors such that an electric current is produced when there is a pronounced temperature difference between alternate junctions. 1-36
- threshing** 6-53
- time-of-day metering** A way of pricing electricity supplied by utilities so that it is more expensive at the times of day when demand is greatest. This reduces the peak load and hence the need to build more generating capacity.
- transportation** 6-23
- energy-intensity of various forms, SB-46 & 47 in America in the 1800s, 6-23
- steamboats on the Mississippi, 1800s, 6-31
- trap** A geological formation containing a porous rock into which petroleum can migrate, capped by an impermeable layer that prevents further migration.
- triple-glazed** Covered with three layers of glass or plastic separated by air spaces (said of windows and solar collectors).
- Trombe wall** A passive solar system in which thermal mass within the living space in the form of a masonry wall is exposed to sunlight through glazing. The thermal energy retained in the mass can be used to heat the interior by conduction and radiation, or vents at the top and bottom of the wall can be opened to regulate convective flows of air.
- turbine** A device that converts the motion of liquid or gas to shaft rotation.
- Twain, Mark** (changes along the Mississippi waterfront, 1800s) 6-31
- U**
- utility, public** An industrial organization, either privately or publicly owned, usually granted a monopoly within a particular area and subject to government regulation. Examples are water, electricity, gas, railroad, and telephone companies.
- first U.S. gas utility, 1816, 6-19
- U-value** A unit of thermal transmittance, used to describe how well a wall, for example, conducts heat. It includes the boundary films of air clinging to the surface of the structure and is based on the temperatures of the environment on the two sides. (In contrast to C, thermal conductance, which is based on the temperatures of the two sides of the wall itself.
- vapor barrier** In building construction, a membrane through which water vapor cannot pass. Activities like cooking, breathing, and bathing make the air inside most buildings much more humid than the outside air. During cold weather, water vapor from the warm inside air penetrates the exterior walls and condenses when it reaches the cooler temperatures inside the walls. The condensed moisture destroys the insulating value of the insulation and promotes rotting of the wood framing. To prevent this a membrane, such as a sheet of polyethylene, aluminum foil, or special kraft paper, is put between the insulation and the warm part of the house.
- Virginia** (1624) 6-7
- volt** 1-83, 1-89 through 1-92
- W**
- water cycle** 2-11
- demonstration by waterwheel in jar, 2-13
- water heater**
- efficiency of, SB-4, SB-44, 1-160
- water power** SB-6&7
- dependence of manufacturing on, 1800s, 6-28
- watt** A measurement of power. 1-83, 1-89, 1-92
- finding, 1-94
- watt-hour** 1-127
- weather stripping** SB-38&39
- wildcat well** An exploratory well drilled in an area where no gas or oil has been extracted previously.
- wind** SB-6&7, 2-7
- windmill, 7-60
- wire** (resistance of various gauges) 1-22
- wood**
- fuelwood for Mississippi steamboats, 1800s, 6-13
- fuelwood in Philadelphia, 1700s, 6-17ff
- Laura & Mary carry in, 1800s, 6-35
- pollution problems, 7-61
- women**
- deference toward, 1800s, 6-24
- difficulty of housework, 1800s, 3-17
- work**
- defined, 1-79, 1-81
- measurement of, 1-82
- XYZ**
- X ray** A type of energetic radiation used in medical diagnosis and treatment.
- zenith** The point in the sky that lies directly overhead.

$$U = \frac{\text{Btu transmitted}}{\text{time in hours} \times \text{area in square feet} \times \text{temperature difference in } ^\circ\text{F of the environment on the two sides of the structure}}$$

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